REMARKS

Claims 1-10, 12, and 19-26 are pending.

Drawing Objections

Attached are black and white drawings to remove these objections. Applicants respectfully request that these objections should be withdrawn.

Interview

Applicants acknowledge Examiner Bolden's time and courtesy during the personal interview conducted on 28 April 2004, with Applicants' representative James E. Ruland. Independent claims 1, 4, 7, 8, 9, 10, and 12 as well as dependent claims 13-18 were discussed. Prior art discussed was JP Publication No. 04-023308 (Nishizawa), U.S. Patent No. 4,123,731 (Kanbara), U.S. Patent No. 4,520,115 (Speit) and German Publication No. DE 3504558 (Hoffman). No exhibit was shown or demonstration conducted. The amendments proposed by the Applicants are depicted above, and a summary of the arguments is presented below.

Arguments

Claim Rejections Under 35 U.S.C. §112, Second Paragraph

Applicants have amended claims 1, 7, 9, 10, and 12 to overcome the rejections that these claims are allegedly indefinite. Particularly, the action alleges that if 70 mol% of SiO_2 is contained in the glass, then the glass must also contain at least 30 mol% of PbO. This composition would equal 100 mol%, and consequently exclude other required components, such as the Na_2O, Al_2O_3, and

ZrO_2. Applicants respectfully submit that one of skill in the art would readily recognize that the 70 mol% as defined in these claims for SiO_2 is an upper limit. However, Applicants have amended the claims to expressly define this limit. Consequently, Applicants respectfully submit that these rejections should be withdrawn, and moreover, the amendments do not narrow the scope of the claims because they merely make explicit what is inherent. In addition, Applicants respectfully submit that these amendments be entered because these rejections have been first raised in the final action, and furthermore, entry of these amendments would remove these grounds of rejection.

Claim Rejections Under 35 U.S.C. §102

Claims 1, 2, 4, 5, 7-10, 12-18, and 20-26 stand rejected as allegedly being unpatentable over Nishizawa. Applicants respectfully traverse these rejections.

Nishizawa fails to teach a glass requiring aluminum oxide and zirconium oxide and being essentially free of titanium oxide. Particularly, Nishizawa teaches less than 10 mol% of titanium oxide, zirconium oxide and aluminum oxide. It fails to teach a glass that is essentially free of titanium oxide, but still has amounts of aluminum oxide and zirconium oxide. Particularly, application example I discloses a glass having a Glass frit (B) with 2 mol% of titanium oxide. Consequently, Nishizawa does not teach the present invention. See page 8 of the translation.

Claim Rejections Under 35 U.S.C. §103

Claims 1-10 and 12-26 stand rejected as allegedly being unpatentable over Kanbara. Applicants respectfully traverse these rejections.

Kanbara teaches a glass used in an ultrasonic delay line. This glass preferably has 1-10% of several oxides, including TiO_2. See column 3, lines 55-61. It fails to teach a glass being essentially free of TiO_2.

Moreover, Kanbara provides insufficient motivation for one of ordinary skill in the art to modify its glass to arrive at the present invention. Particularly, all of the examples of Kanbara fail to teach a glass having both Al_2O_3 and ZrO_2 and being essentially free of TiO_2.

Claims 1-3, 7, 9, 10, 12, 13, 15, 17-20, 22, and 24-26 stand rejected as allegedly being unpatentable over Speit and claims 1-26 stand rejected as allegedly being unpatentable over Hoffman. Applicants respectfully traverse these rejections.

Particularly, the action presented theoretical compositions from the references' broad disclosures that allegedly render obvious the claimed invention. However, Applicants respectfully submit that there is insufficient motivation to arrive at these theoretical compositions as alleged in the Action.

Hoffman discloses two examples, one of which does not include Al_2O_3 or ZrO_2, while the second example fails to include ZrO_2. See Hoffman examples at pages 5 and 6 of the translation which is attached for the Examiner's convenience. Consequently, Applicants respectfully submit that there is insufficient motivation within Hoffman to provide the requisite motivation as alleged in the Action to come up with the "theoretical composition." Rather, the Action is using impermissible hindsight.

With respect to Speit, the same deficiencies hold true. Particularly, only one of the examples in Speit includes both ZrO_2 and Al_2O_3, but in that example there are insufficient amounts of PbO and excessive amounts of K_2O. See Speit examples at column 5-6. Consequently, Applicants

respectfully submit that there are no preferences or examples in the reference to motivate one of skill in the art to arrive at the "theoretical composition" as alleged in the Action. Applicants respectfully submit that this rejection should be withdrawn because impermissible hindsight has been used. Thus, Applicants respectfully submit these rejections should be withdrawn.

With respect to the amendments incorporating glass properties, Applicants respectfully submit that these amendments should be entered because they facilitate allowance of the application.

In view of the above remarks, favorable reconsideration is courteously requested. If there are any remaining issues which can be expedited by a telephone conference, the Examiner is courteously invited to telephone Counsel at the number indicated below.

The Commissioner is hereby authorized to charge any fees associated with this response or credit any overpayment to Deposit Account No. 13-3402.

Respectfully submitted,

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Translator's Note:

The sentence beginning with "Bei einer Verzögerung um $\pi/2$ [With a delay by $\pi/2$]," on German page 6, line 17 from the bottom (English page 5, line 10), is apparently incomplete, missing at least a verb that would be placed between "is" and "from," also on English page 5, line 10.

CERTIFICATION OF MAILING

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The request for examination according to §44 of the Patent Law has been made.

(54) Optical Glass with a Photoelastic Coefficient That is Proportional to the Wavelength of Electromagnetic Radiation

(57) A new optical glass with a photoelastic coefficient in the wavelength range of between 360 nm and 5300 nm of electromagnetic radiation, which for a wavelength interval of more than 200 nm is proportional to the wavelength, with a deviation of less than ±6%, consists of (% by weight): PbO 60-76, SiO_2 15-30, B_2O_3 0-12, GeO_2 0-5, P_2O_6 0-5, Li_2O + Na_2O + K_2O + Rb_2O + Cs_2O 0-6, MgO + CaO + SrO 0-8, BaO 0-10, oxides of rare earths 0-3, Al_2O_3 0-6, TiO_2 + ZrO_2 0-5, ZnO 0-4, CdO 0-2, As_2O_3 + Sb_2O_3 0-3, whereby PbO can be replaced completely or partially by Ti_2O or Bi_2O_3.

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Optical Glass with a Photoelastic Coefficient That is Proportional to the Wavelength of Electromagnetic Radiation

Claims:

1. Optical glass, characterized by a photoelastic coefficient in the wavelength range of between 360 nm and 5300 nm of electromagnetic radiation for a wavelength interval of more than 200 nm proportional to the wavelength with a deviation of less than ±6%.

2. Glass according to claim 1, characterized in that it has the following composition in % by weight based on oxide:

PbO	60-76%
SiO_2	15-30%
B_2O_3	0-12%
GeO_2	0-5%
P_2O_5	0-5%
$Li_2O + Na_2O + K_2O + Rb_2O + Cs_2O$	0-6%
MgO + CaO + SrO	0-8%
BaO	0-10%
Oxides of rare earths	0-3%
Al_2O_3	0-6%

$TiO_2 + ZrO_2$	0-5%
ZnO	0-4%
CdO	0-2%
$As_2O_3 + Sb_2O_3$	0-3%.

3. Glass according to claim 1 or 2, whereby PbO is completely or partially replaced by Tl_2O or Bi_2O_3, whereby the amount of PbO in mol% is replaced in each case by approximately half the same amount in mol% of Tl_2O or Bi_2O_3.
4. Glass according to one of claims 1 to 3, wherein other oxides up to a total of 2%, not specifically indicated, are included, and wherein up to 2% of the oxides are replaced by corresponding halides and/or chalcogenides and/or nitrides.
5. Use of a glass according to one of claims 1 to 4, alone or in combination with other materials, for the construction of achromatic retardation plates of electromagnetic waves.
6. Optical glass according to one of claims 1 to 4, characterized by a division ratio of the values of the photoelastic coefficients K_1 (λ_1) and K_2 (λ_2) that is equal to that of the wavelengths λ_1 and λ_2 from the wavelength interval between 360 nm and 5300 nm.
7. Glass according to one of claims 1 to 4, wherein the content of PbO and/or Tl_2O and/or Bi_2O_3 is set so that the values of the photoelastic coefficients K_1 (λ_1) and K_2 (λ_2) have the same division ratio as the wavelengths λ_1 and λ_2 from the wavelength interval of between 360 nm and 5300 nm.
8. Use of a glass according to claims 6 and 7 for the production of retardation plates that have the same delay, measured in multiples of the respective wavelength, for each of two different wavelengths of electromagnetic radiation.

Description

The invention relates to a new optical glass with a photoelastic coefficient in the wavelength range of between 360 nm and 5300 nm of electromagnetic radiation, which for a wavelength interval of more than 200 nm is proportional to the wavelength with a deviation of less than ±6%.

Isotropic glasses are optically anisotropic by mechanical compressive stress or tensile stress. In the case of single-axle stress conditions, the optical axis is parallel to the direction of the compressive stress or tensile stress. The refractive indices for electromagnetic waves with a direction of oscillation parallel and perpendicular to the stress direction $n_{\parallel}$ or $n_{\perp}$ are generally different. Consequently, for these two polarization directions, a difference in optical path lengths for electromagnetic waves of $(n_{\parallel} - n_{\perp}) \cdot L$ occurs, whereby L is the geometric path in the anisotropic medium.

The difference of $n_{\parallel} - n_{\perp}$ is proportional to the mechanical stress σ with the photoelastic coefficient K as a proportionality constant

$$n_{\parallel} - n_{\perp} = K \cdot \sigma$$

This means that the refractive index difference $n_{\parallel} - n_{\perp}$ for the two directions of oscillation of electromagnetic waves can be adjusted or changed by selection of a suitable value of the compressive stress or tensile stress. Glasses under such a single-axle stress condition can be used for the construction of retardation plates (P 34 38 607.6). The mode of action of such a retardation plate can be explained based on Fig. 1: In a plane-parallel plate P1, a single-axle stress condition is produced by a compressive stress 6. An electromagnetic wave with a direction of oscillation that is inclined by 45° from the stress direction passes through perpendicular to the stress direction and perpendicular to two plane-parallel faces in the plate. The electromagnetic

wave can be broken down into two partial waves with a direction of oscillation that is parallel and perpendicular to the stress direction. Before the electromagnetic wave enters into the glass plate, no phase difference is between the two partial waves, such that by superimposing the two partial waves again on the original direction of oscillation, the electromagnetic wave results. In the plate that is under mechanical stress σ, however, there is a phase difference between the two partial waves, which increases with the growing path in the plate, because of the refractive index difference $n_{\parallel} - n_{\perp}$. If the plate has thickness L, the optical path difference, if both partial waves leave the plate, is thus:

$$(n_{\parallel} - n_{\perp}) \cdot L = K \cdot \sigma \cdot L$$

The phase difference

$$\Delta\theta = \frac{2\pi}{\lambda} K \cdot \sigma \cdot L$$

between the partial waves corresponds to this optical path difference.

In many materials, the photoelastic coefficient K in the visible spectral range is almost independent of the wavelength λ of the electromagnetic radiation. Phase difference $\Delta\theta$ at constant stress σ and constant thickness L of the plate therefore depends on wavelength λ. To obtain a desired phase delay between the electromagnetic partial waves, in each case thickness L of the plate or mechanical stress σ must be newly specified for different wavelengths. A specific phase difference to be set simultaneously for several different wavelengths is even impossible in this case.

The purpose of the invention is to find a composition range for an optical glass for which in the transmission range between 360 and 5300 nm, the photoelastic coefficient K in specific wavelength ranges is proportional to wavelength λ. If the glasses according to the invention are put under a mechanical stress, achromatic retardation plates can be produced. Such a glass

according to the invention has, e.g., the composition in % by weight and with an oxide base (Example 1):

PbO	71.0%
SiO_2	27.3%
$Na_2O + K_2O$	1.5%
As_2O_3	0.2%

From the glass according to the invention, a plane-parallel plate was cut and put under such a mechanical compressive stress that for $\lambda = 496$ nm, a phase difference of $\pi/2$ for the two partial waves with directions of oscillation perpendicular and parallel to the stress direction was produced ($\lambda/4$-plate). With a delay by $\pi/2$, a circularly polarized wave is from the linearly polarized electromagnetic wave that enters under an angle of 45° to the optical axis. An analyzer behind the retardation plate then lets through only half the relative intensity of the electromagnetic wave regardless of its orientation. Based on the solid curve in Figure 2, it is shown that in the wavelength interval between 472 and 672 nm, the intensity is actually reduced to half of the original intensity with a margin of error of ±3% of the full deviation.

For comparison, the relative intensity of linearly polarized electromagnetic waves after passing through both a retardation plate that does not have the property of achromatism and an analyzer that is connected behind it is also indicated by broken lines in Fig. 2. In this case, the wavelength interval, in which the transmitted intensity is reduced to one-half, i.e., the delay between the two partial waves is $\lambda/2$, is quite small. In this – typical, however – example of a commercial retardation plate, this is only 476 to 516 nm.

By selection of a higher (lower) concentration of PbO, the interval in which the property of achromatism is very well met can shift back to longer (shorter) wavelengths. In this case, the

wavelength intervals in which the retardation plates are achromatic are larger (a little smaller). The composition of a glass according to the invention, which has a lower PbO concentration in comparison to Example 1, is, in % by mass, based on oxide:

PbO	68.6%
SiO_2	24.7%
B_2O_3	2.4%
Al_2O_3	0.4%
K_2O	1.2%
Na_2O	1.0%
NaCl	1.0%
As_2O_3	0.5%
Sb_2O_3	0.2%

For this glass according to the invention, photoelastic coefficient K of between 400 and 600 nm is proportional to the wavelength with a deviation of at most 6%.

If PbO is replaced completely or partially in the lead-silicate glasses according to the invention by a specific Tl_2O or Bi_2O_3 content, these glasses also show the claimed properties, i.e., the photoelastic coefficient in the wavelength range of between 360 nm and 5300 nm for a wavelength interval of more than 200 nm is proportional to the wavelength with a deviation of less than ±6%. In these glasses, the amount of PbO in mol% in each case must be replaced by approximately half the same amount in mol% of Tl_2O or Bi_2O_3.

For two specified wavelengths λ_1 and λ_2 from the wavelength interval of between 360 nm and 5300 nm, lead, thallium and bismuth silicate glasses of the claimed composition ranges have

photoelastic coefficients, whose values have the same division ratio as the related wavelengths λ_1 and λ_2.

From the above-mentioned glasses, retardation plates can be produced that have the same delay, measured in multiples of the respective wavelength, for each of two different wavelengths of electromagnetic radiation.

The retardation plates that are produced from the glasses according to the invention, which are achromatic only for a solid wavelength interval, can be combined with other retardation plates that need not be achromatic, such that the property of achromatism is pushed over into another wavelength interval.

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